Design, Modeling, and Development of Precision Apertures

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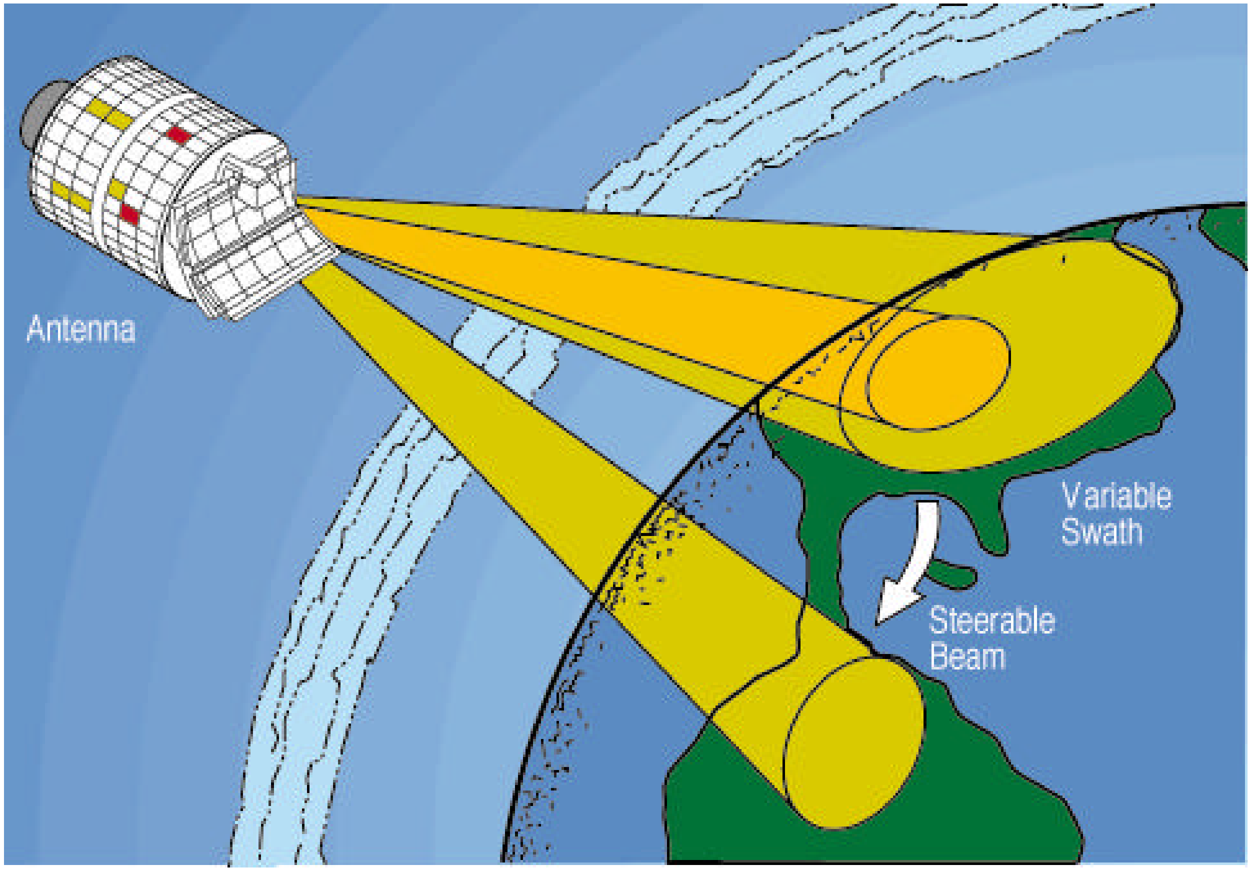
Characteristics of Smart Antennas

1. Two functions achieved by changing the reflector shape
   (1) Beam Steering -- first mode
   (2) Beam Shaping -- second mode

2. Advantages of using smart antennas
   (1) Transmitted power maximization under the atmospheric disturbance or thermal distortion of the reflector
   (2) Ability to vary the coverage area
   (3) User defined radiation pattern

Mechanically Active Antennas



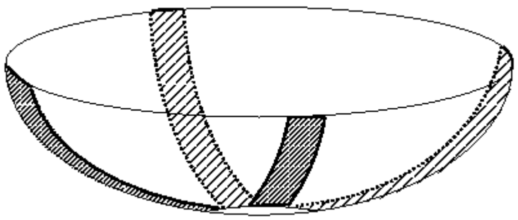
Modeling issues

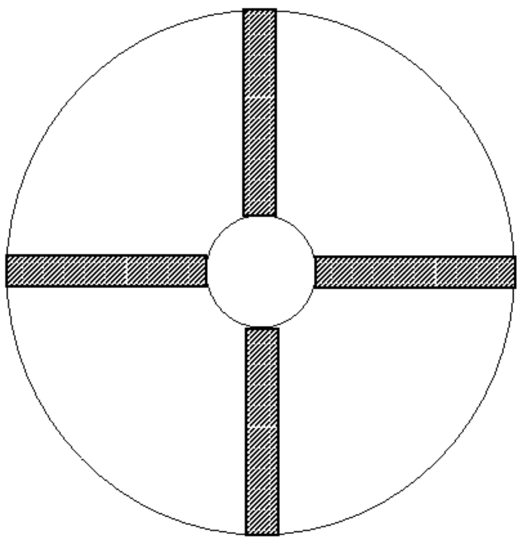
1. Quasi static shape control

2. Boundary Value Problems
   (8 undetermined coefficients)

3. The actuation forces need to be expressed
   analytically and applied as boundary conditions

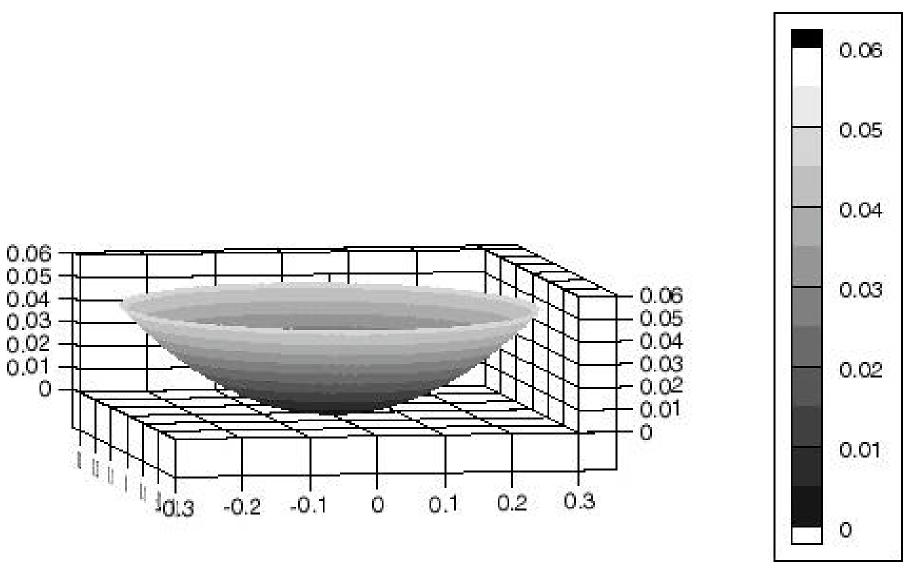
Doubly Curved Aperture Antenna

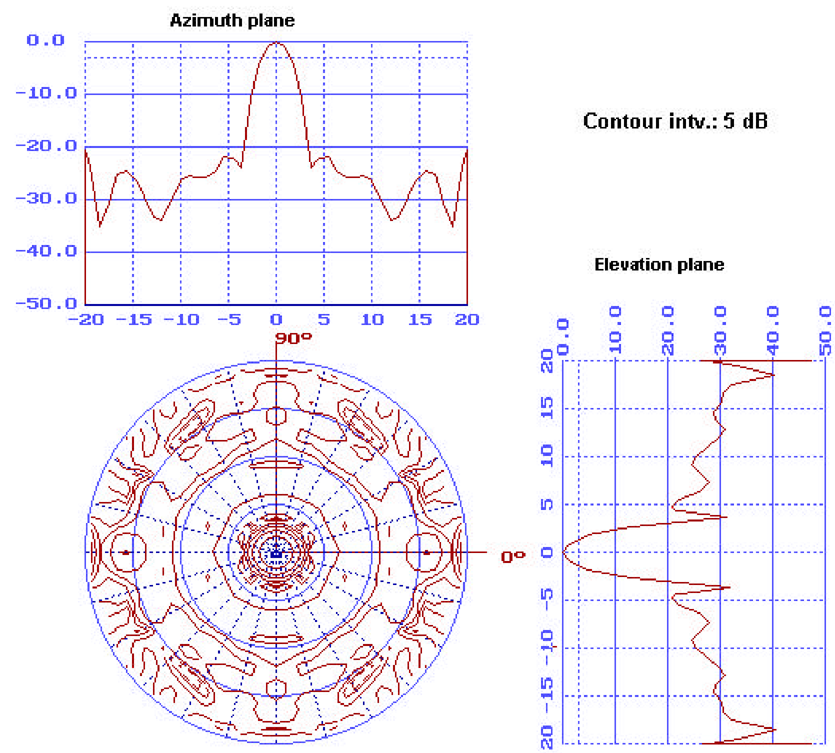




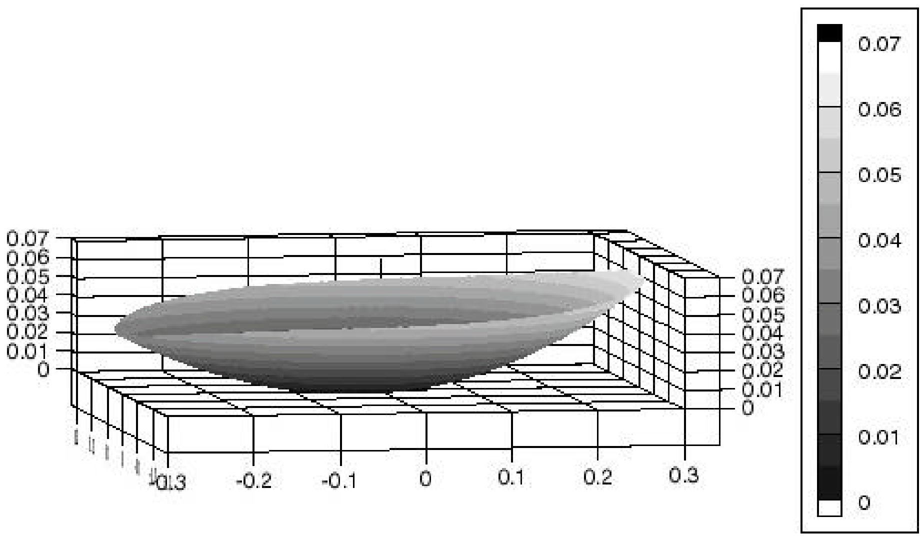
- Outer radius : 0.3 (m)
- Inner radius : 0.01 (m)
- Radius of curvature : 1 (m)
- Material of the reflector :
  Metalized LEXAN of
  (m) thickness
- Actuators : Four Thunder PZT
  Actuators
- Frequency of Signal : 11.8 GHz

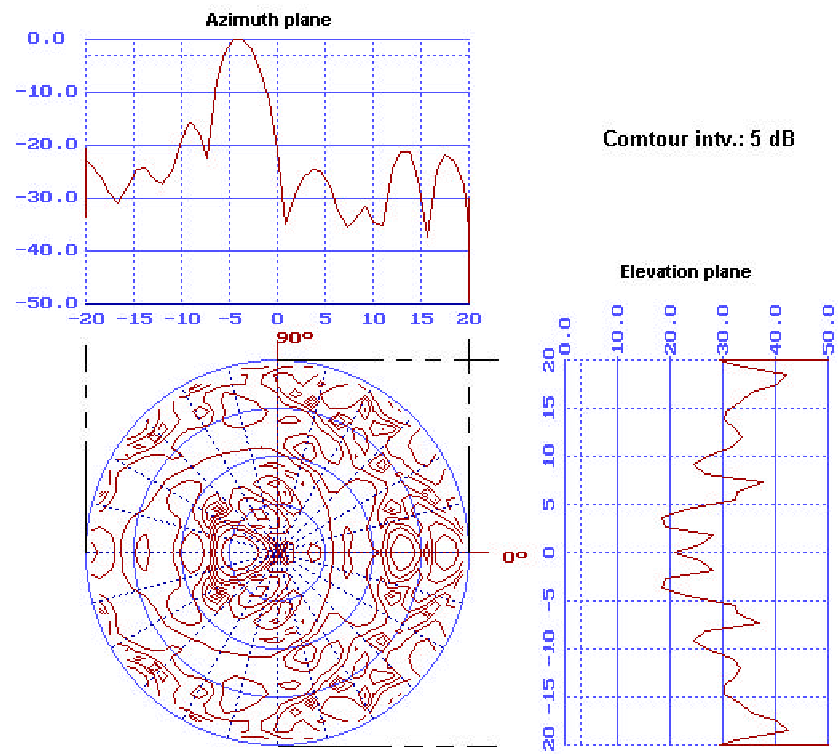
Results (Undeflected shape)



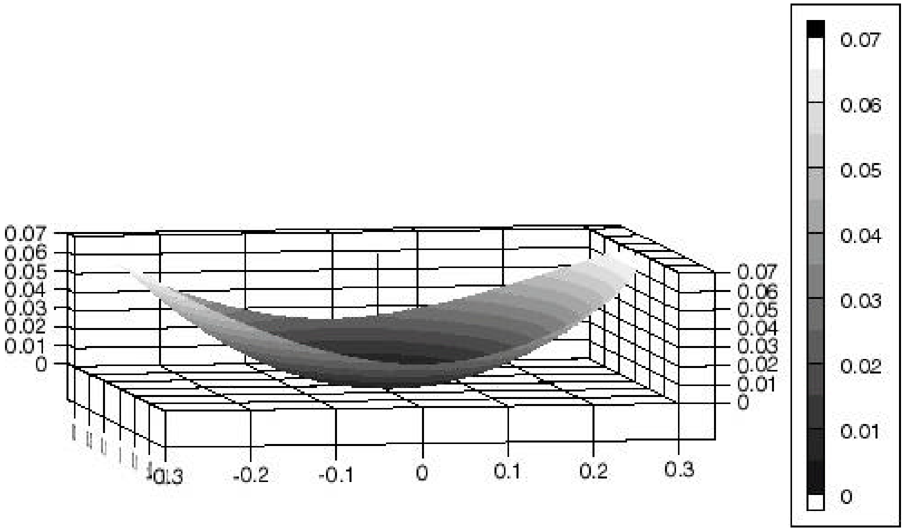


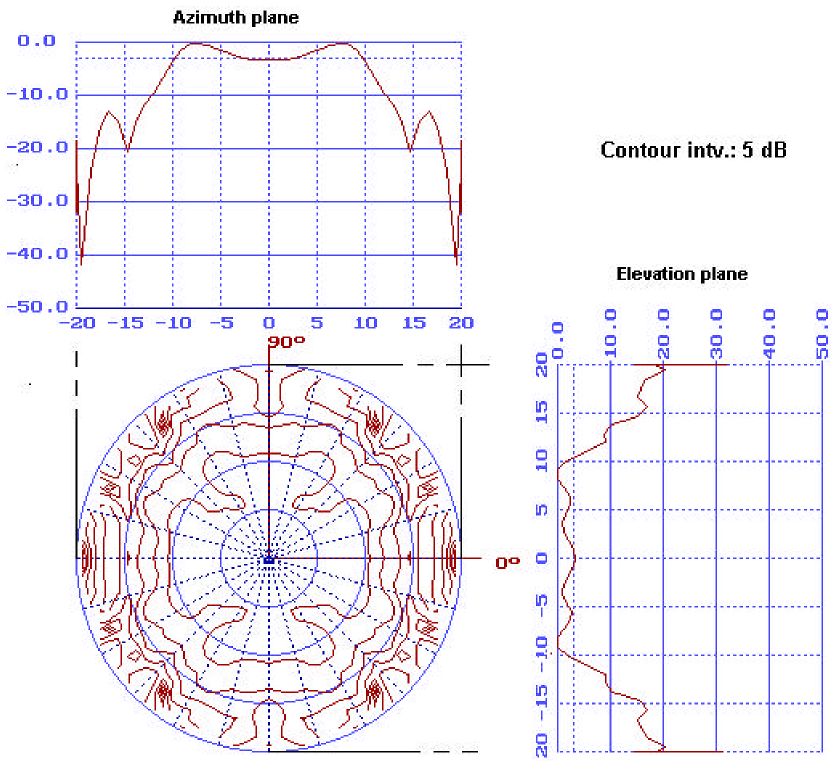
Results (1st Mode)



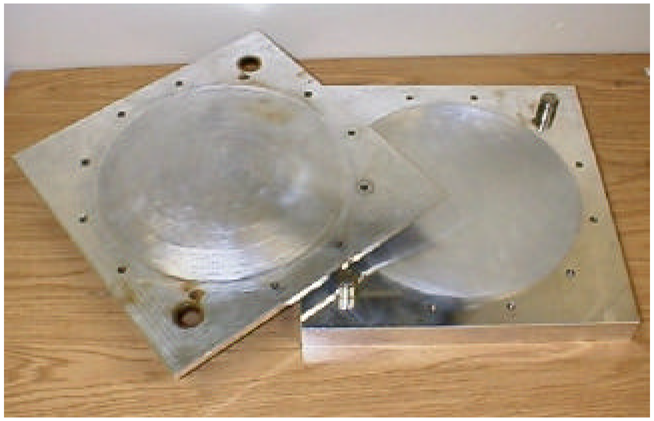


Results (2nd Mode)

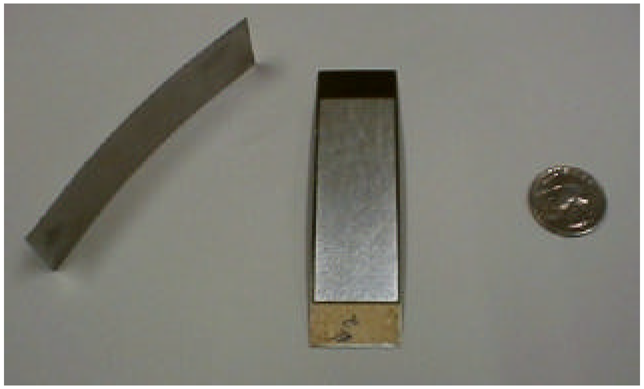




Construction of Doubly Curved Smart Antenna



Mold for forming a small scale doubly curved reflector



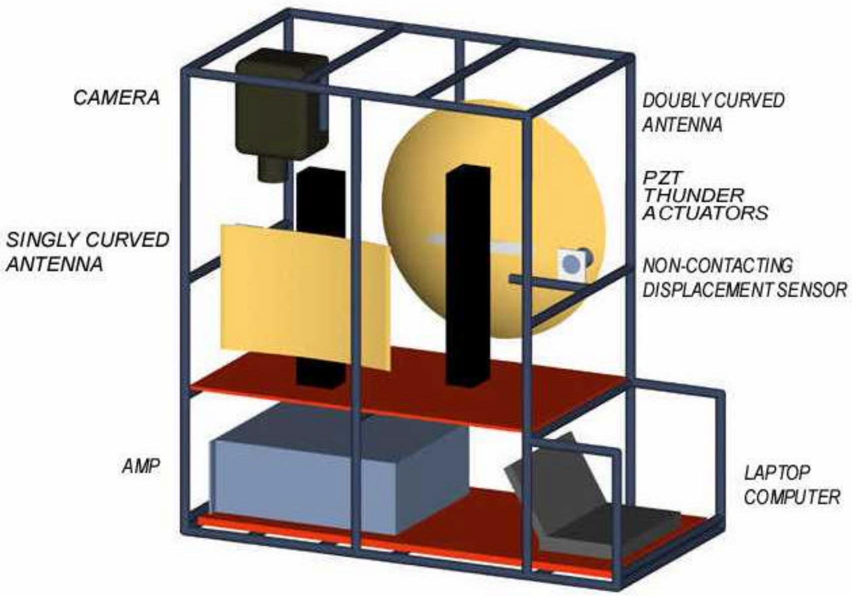
Thunder actuators

Actual Model of Doubly Curved Smart Antenna

Front surface

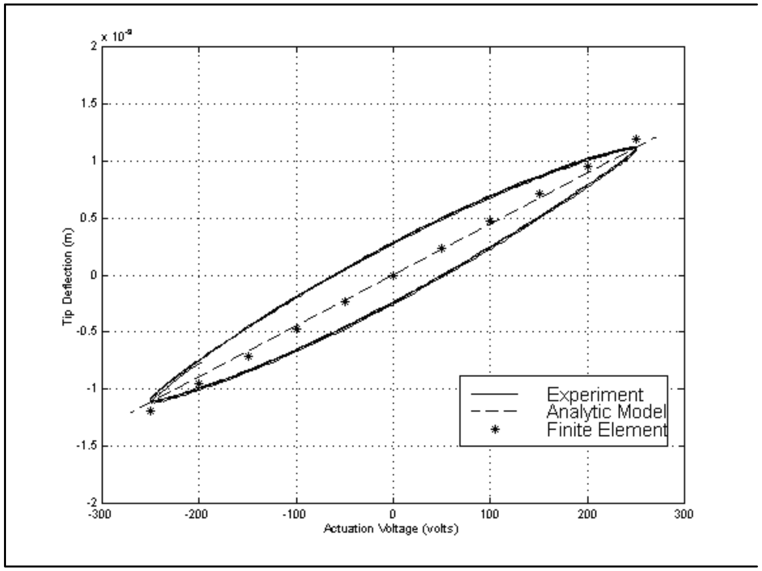
Back surface

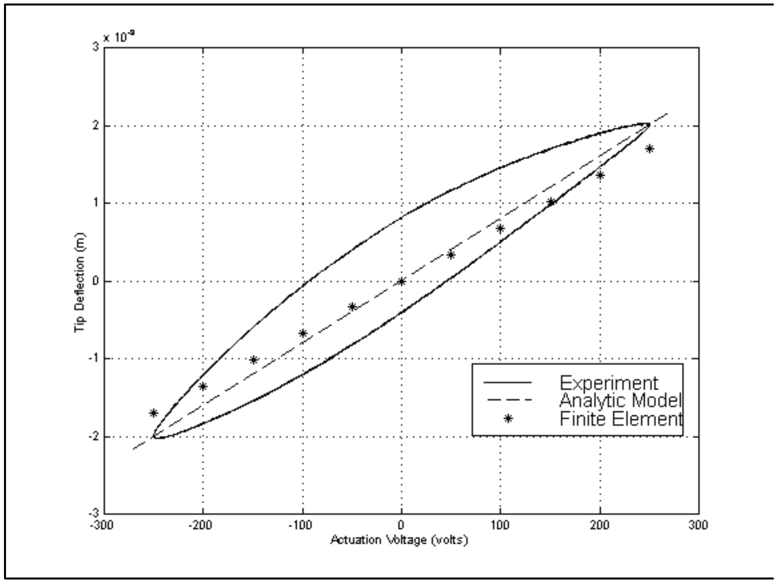
Zero-G Testing of Aperture Antennas



• Testing aboard NASA's KC135-09 Aircraft

Zero-G Testing of Aperture Antennas (Con't)

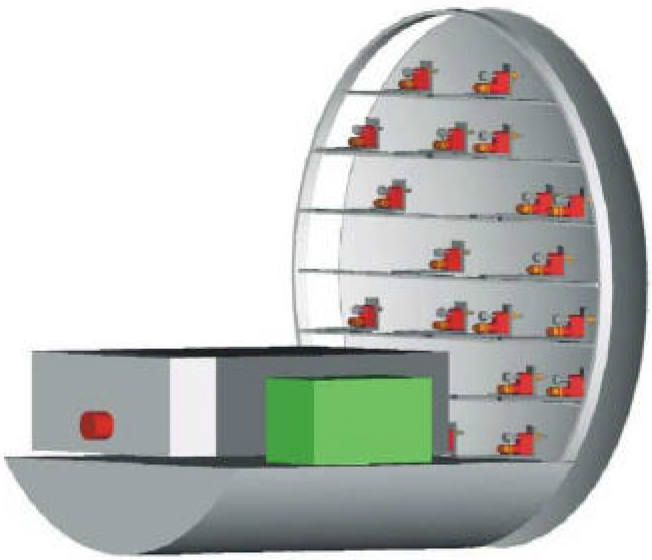




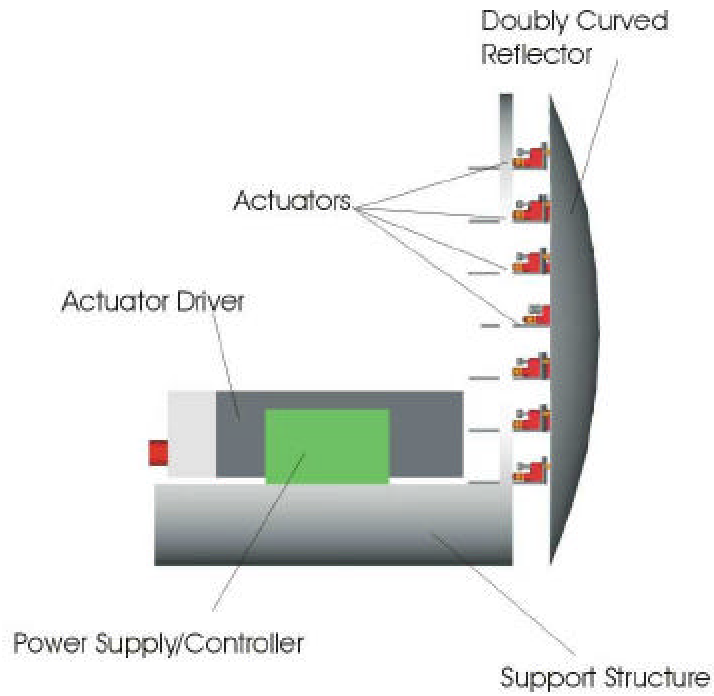
Point Actuated Precision Apertures

1. Useful life time of geostationary communication satellites is getting longer
2. Satellite antennas designed to cover one area are being used to cover different areas during its life time.
3. It is required that satellite antennas have ability to change their radiation pattern
4. Advanced Communications especially space based technology represents an enabling technology for future military applications
5. Potential spin-offs: Include Low cost MRI units, Large Telescopes. Missile Defense

Smart (Point Actuated) Contour Beam Antenna



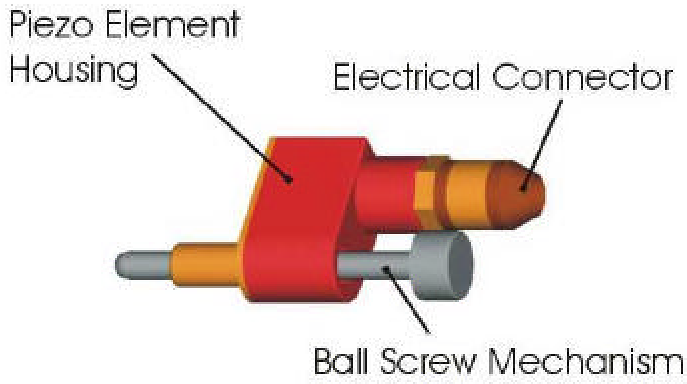
Perspective View



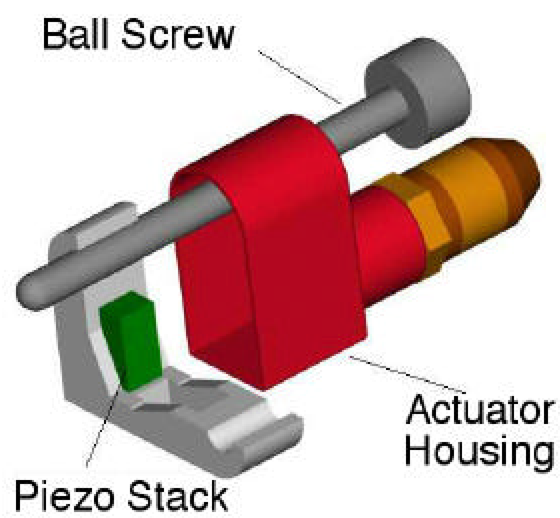
Side View

- **Utilizes up to 40 Picomotor point actuators to actuate an antenna surface**

Point Actuation



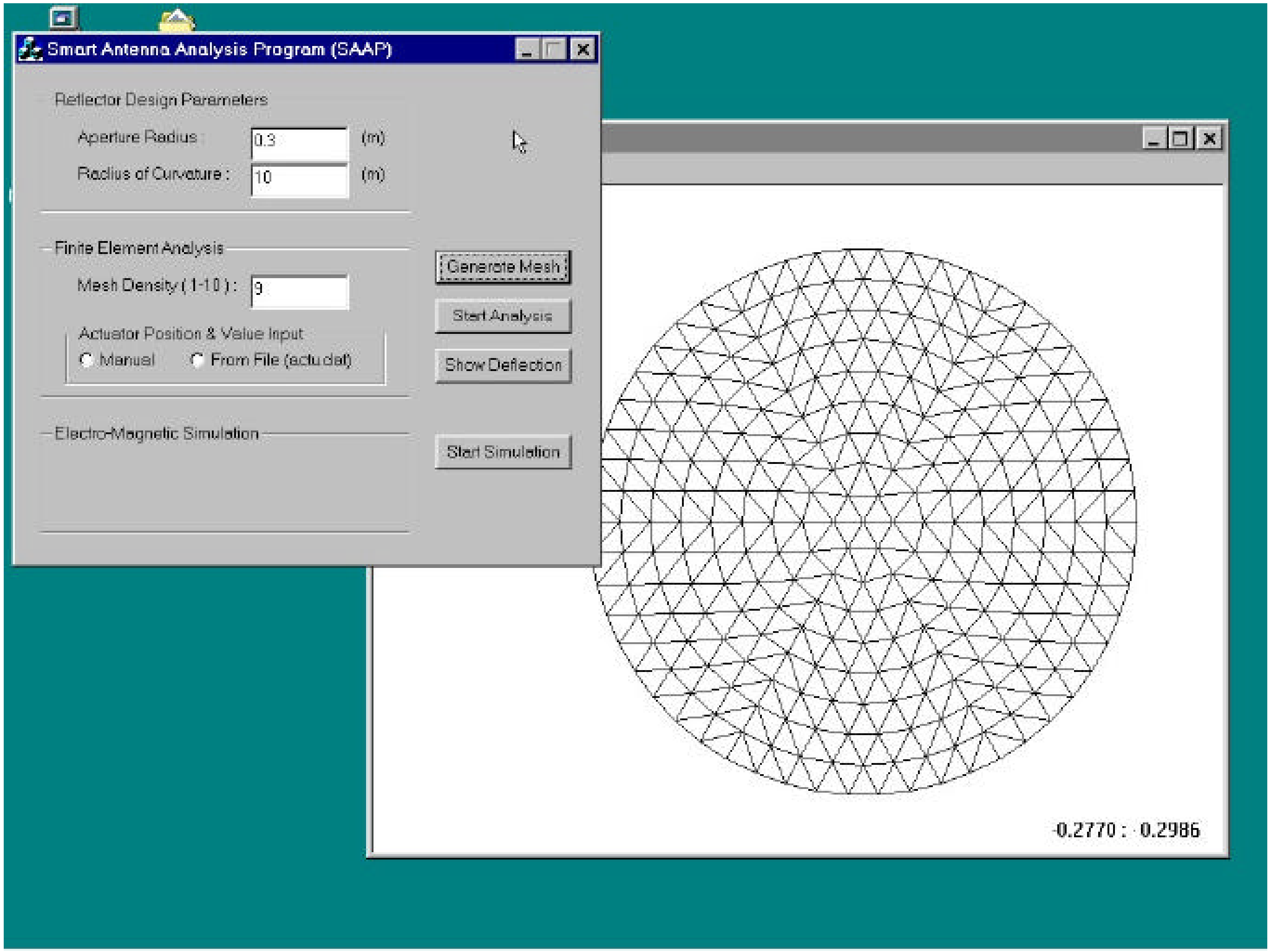
- Actuation stroke = 0.5 mm/min
- Actuation force = 10 Newtons
- The piezoelement is a stack actuator in D33 mode
- Piezoelement Stick-Slip mechanism



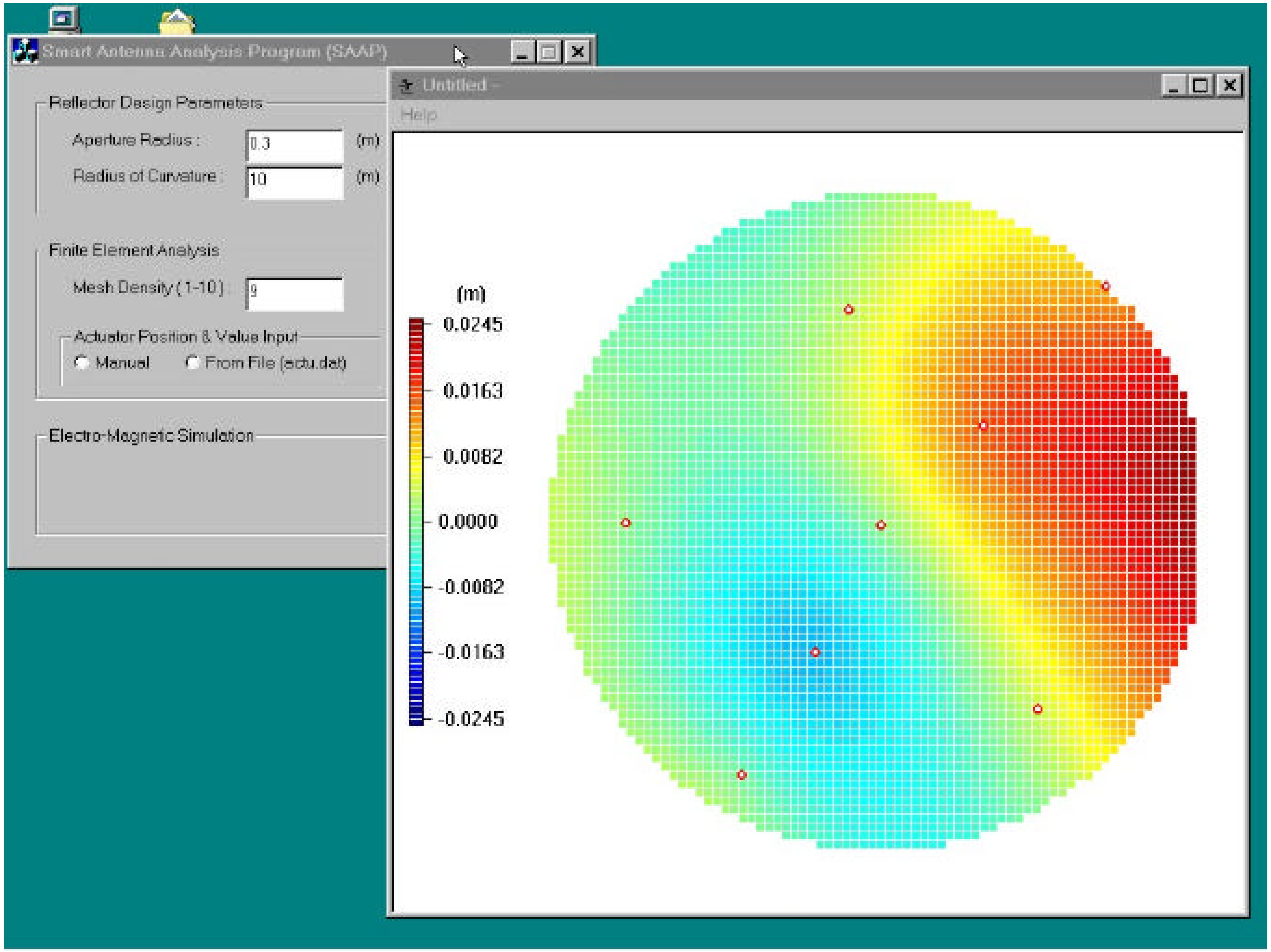
Contour Beam Antenna Adjustment Algorithm

- Assume initial shape
- U.V. Space template
- Calculate Far Field pattern
- Form Cost Function
- Take Cost function derivatives (in terms of actuator amplitudes
- Adjust Actuators via steepest decent and Genetic Algorithm
- Form new surface

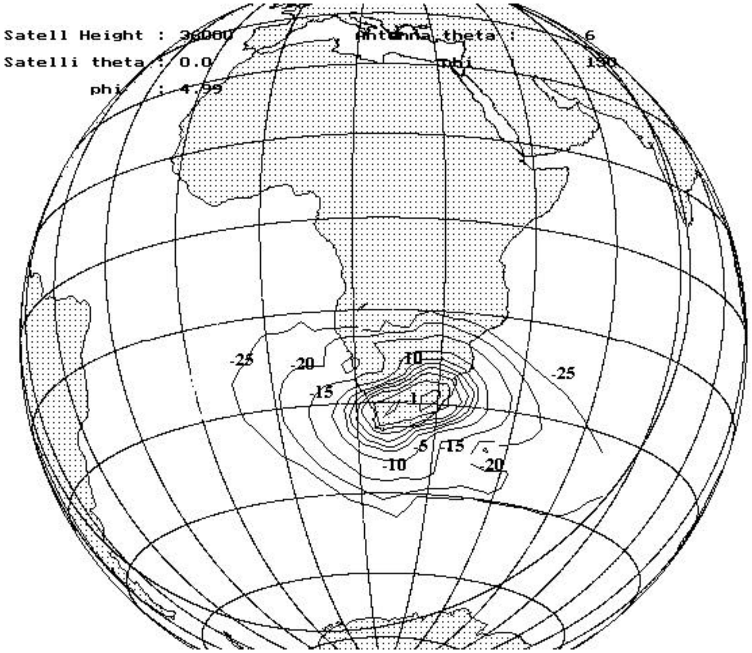
Smart Antenna Analysis Program

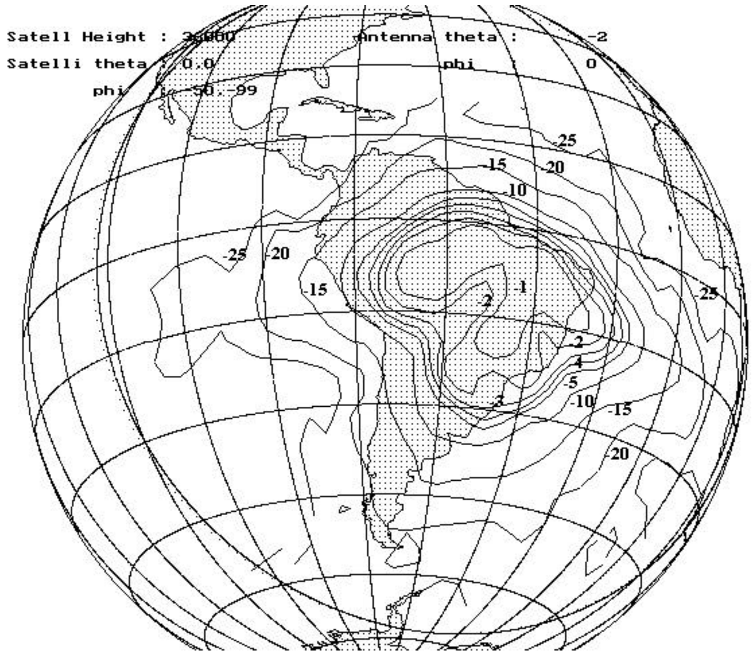


SAAP (Continued)



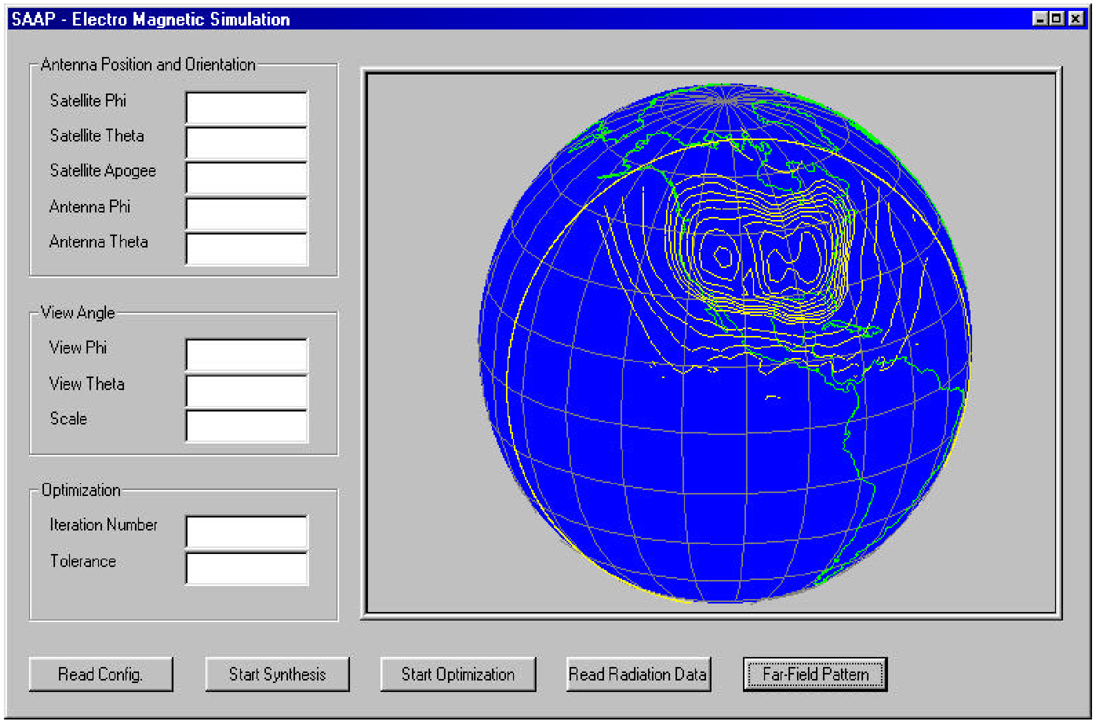
Antenna Data (Brazil/SouthAfrica)





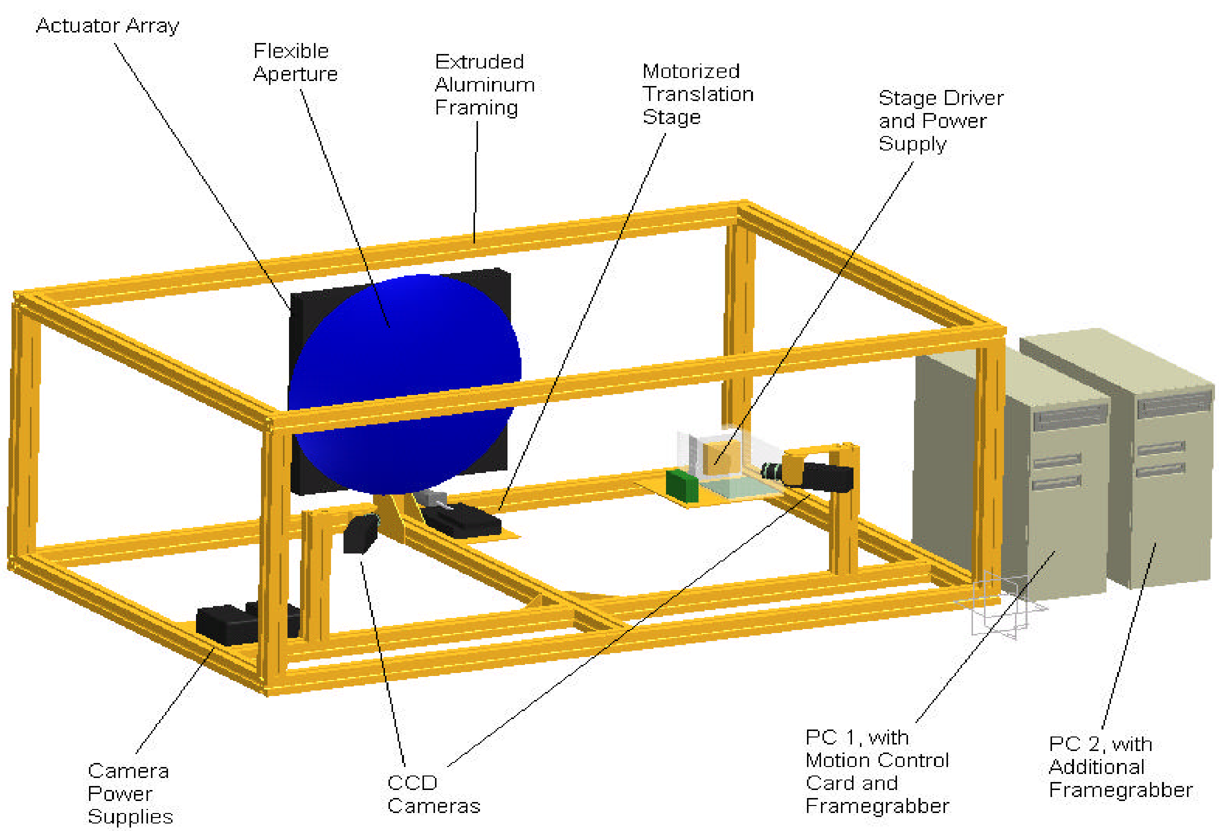
- Same Antenna being used to send a signal to Brazil or South Africa

SAAP- Electromagnetic Info

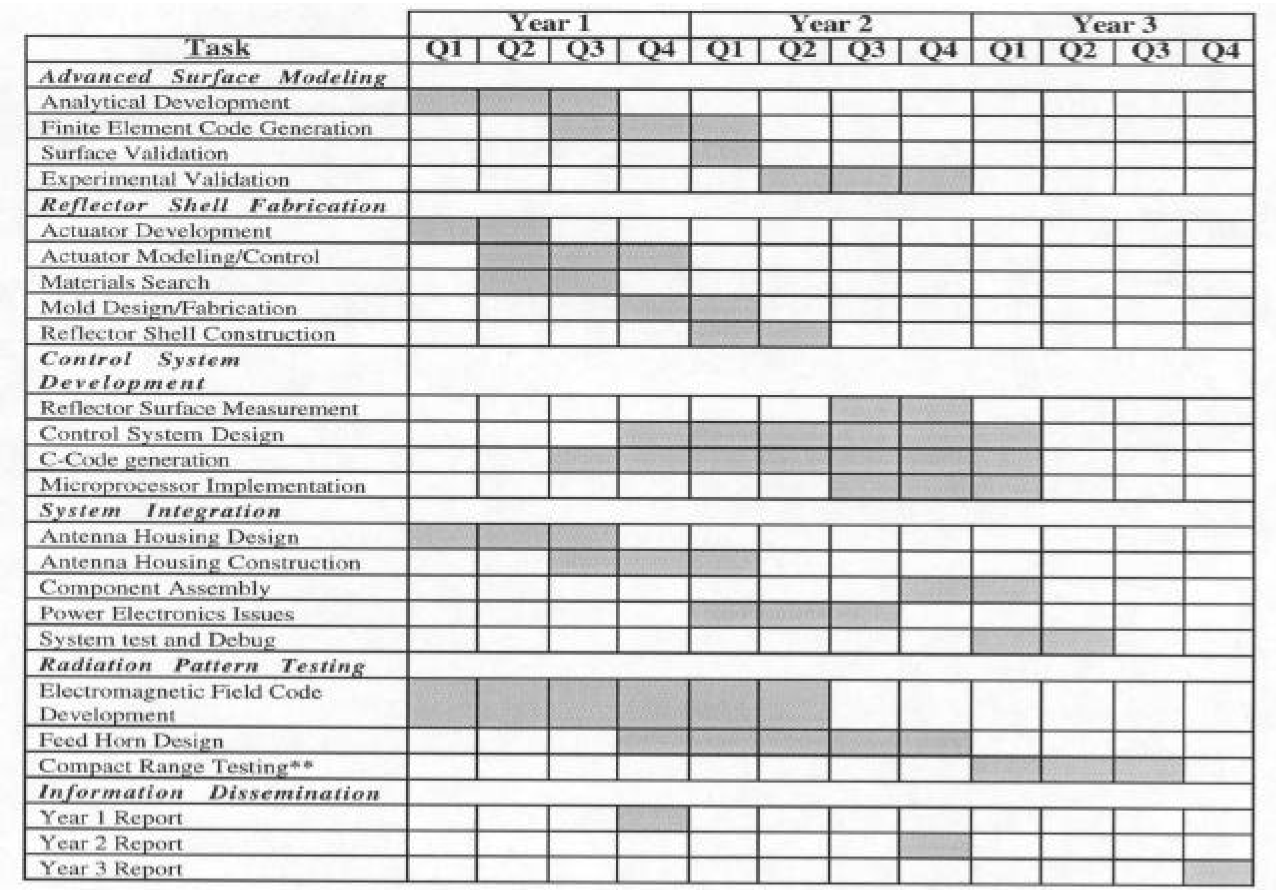


•FEM and EM codes are included in one program to calculate the far field radiation Pattern

Surface Validation Mechanism



Accomplishments



- **Al first year task on Gantt chart have been completed (Except Antenna Housi**

Major Milestones

•Singly and Doubly Curved Aperture Antennas have been analytically modeled and tested (December 1999)

•A doubly curved piezoelectrically actuated reflector structure was built and tested. (December 1999)

•Zero Gravity testing was concluded (March 1999)

•Point Actuated Antenna Simulation has been Completed (May 2000)

•Field Testing will conclude in late Summer 2000

•Building of Antenna Construction Facility (Summer 2000)

•Surface Validation Experiment (Summer 2000)

•Initial Point Actuated prototype (December 2000)

•Surface Actuation Optimization completion (June 2001)

Potential Issues

- Access to proper surface materials
- Actuator Hysteresis
- Power Demand Issues
- Actuator Noise
- Partnering issues